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The Effect Of Kinesio Tape On The Knee And Hip Kinematics And Pain Level In Athletes With Anterior Knee Pain

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Review Article

**THE EFFECT OF KINESIO TAPE ON THE KNEE AND HIP
KINEMATICS AND PAIN LEVEL IN ATHLETES WITH
ANTERIOR KNEE PAIN****Raed Saud Saeed**

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Abstract

Anterior knee pain (AKP) is a clinical condition that is experienced over the anterior knee and can be aggravated by practical activities such as squatting and going up and down stairs. AKP is one of the most common knee overuse injuries and it intensifies when the kneecap moves incorrectly and rubs against the lower part of the thigh bone. The biomechanical factors implicated in AKP include decreased muscle strength, distorted mechanical loading, lower limb kinematics and patterns of muscle activation during running. Kinesio tape is one of the rehabilitation methods used to reduce AKP and increase the performance of athletes.

In order to investigate the effect of KT on pain levels in AKP, the research adopted a cross-sectional study design. The study involved 24 runners aged between 18 and 50 years. The research used the 3D Gait Biomechanical Analysis system to analyze hip and knee kinematics. In the research, a baseline questionnaire, Kujala questionnaire and OSTRC Overuse injury questionnaire were utilized to collect data regarding the participants' characteristics and the severity of their knee pain. The data was analyzed using SPSS to determine the relationships between the study variables.

The findings show that KT is an important rehabilitation instrument that can be used by athletes to reduce AKP. KT does not affect hip and knee kinematics during running. Available evidence supports the findings of this study and shows that KT helps to maintain the joint within physiological limits as well as prevent chances of mechanical overload. This research focused on the short-term impact of KT and thus proposes that future studies focus on the long-term impact of KT on the reduction of pain level in patients with AKP.

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INTRODUCTION:**POPULARITY OF RUNNING**

Running is one of the most popular types of exercise, especially in the US where over 10 million people are reported to engage in running [1]. Currently one of the biggest marathons is the New York City marathon, in which more than 50,000 participants compete every year [1]. Running as a sport began as a movement which produced national athletic celebrities, and gradually it became a mainstream exercise and recreational activity [2,3]. Nowadays, almost every city in Western society has its own marathon or recreational running event. The most important reasons people participate in these running events are to experience the positive health effects of running and to improve personal performance [3,4]. The European running market has estimated that 50 million people in Europe are running on a regular basis. Running-related expenditures have reached approximately 9.6 billion euros a year, making running one of the largest and fastest growing markets in the world [5]. Running is also a sport frequently practiced in the Netherlands, where its popularity has significantly increased in recent years [3]. In the Netherlands, more than 2 million people engaged in regular running in 2014, which is around 12.5% of the Dutch population [6].

RUNNING-RELATED INJURIES

Although running offers several health benefits, the main disadvantage of running is the increased risk of musculoskeletal injuries [4]. The increase in the number of runners has therefore resulted in an increase in the number of running-related injuries (RRIs). One of the major reasons for terminating a running program is injury. Some studies have found high incidences of RRIs, but estimations range from 3.2% to 84.9%. This wide variation arises from differences in the studies' populations, follow-up period and injury definition [6]. For instance, in the Netherlands, RRIs in 2010 were reported to be 350,000, which doubled in 2014 to 710,000 [6]. Another study has shown that the most common site of injury among runners is the knee [9]. Runner's knee is also the most common type of injury among athletes. Runner's knee is also known as patellofemoral pain syndrome (PFPS). Patellofemoral pain syndrome (PFPS) is the most frequently diagnosed orthopaedic pathology in individuals who are physically active, followed by iliotibial band syndrome (ITBS), fasciitis plantaris, knee meniscus injury and medial tibial stress syndrome (MTSS) [9].

ANTERIOR KNEE PAIN (AKP)

AKP is the pain experienced at the front and centre of the knee. AKP is one of the most common knee problems and it occurs more frequently in women. An estimated 25% of athletes suffer from anterior knee pain; this is higher than the rate for the general population [11]. Anterior knee pain is caused by continuous stress on the musculotendinous structures that enclose the knee, and it is exacerbated in athletes by cycling and running. It's common in athletes due to the increased intra-articular stress on patellofemoral joint often caused by an athlete's abnormal biomechanics mainly during drop landing with knee valgus [17]. AKP is typically experienced when individuals exercise for a prolonged period and it is characterized by diffuse pain in the front of the knee. Individuals experiencing AKP suffer excessive stress on the patellofemoral joint in instances of abnormal structures of the lower extremities, such as deteriorated hip rotation control, amplified feet pronation, tibia rotations and femoral anteversion [29].

AKP in athletes is frequently a result of patellofemoral pain (PFP) [14]. Patellofemoral pain syndrome (PFPS) is a common overuse injury that occurs in cases when the kneecap is out of alignment; this results in the kneecap cartilage wearing out, causing pain around the kneecap [14]. Most young AKP patients suffer from patellofemoral pain syndrome. Dynamic valgus of the lower extremity is the key determinant for the development of PFP, which results in lateral patellar maltracking [8]. Dynamic valgus is caused by weak hip muscles and the eversion of the rear foot with pes pronatus valgus. However, knee pain is a regular musculoskeletal complaint that affects an average of 25% adults seeking medical attention for musculoskeletal complaints [13,16]. Knee pain affects mobility, limits function and considerably reduces the quality of life.

Various problems cause AKP, such as runner's knee, maltracking of the patella, lateral compression syndrome and chondromalacia of the patella, amongst other [10]. It is the gliding of the patella over the lower part of the thigh bone (femur) that causes the pain felt during exercise. AKP intensifies in cases where the kneecap fails to move properly and rubs against the lower part of femur. This may happen due to the abnormal position of the kneecap in cases of weakness or tightness of the thigh muscles on the front and back, or in case of over exercise that stresses the kneecap, and it might also happened by putting the feet flat [11]. AKP is common in overweight people, athletes, teenagers and young adults who are physically active and especially

women and people with past incidences of knee dislocation. Research shows the prevalence of AKP among young people, which includes a range from sedentary adolescents to military recruits in basic training, to be 12%-45% [11]. If not well-managed, AKP can result in disability and psychological morbidity. However, the best way to manage AKP remains controversial and its treatment is characterized by high rates of failure.

KINEMATIC AKP

The aetiology of AKP is considered to be multifactorial. However, there are various biomechanical factors such as decreased muscle strength, distorted mechanical loading, abnormal lower limb kinematics and patterns of muscle activation during running that are associated with this condition, although it is not clear which factors are of clinical importance [17]. Therefore, clinicians should target the factors that are supported by the most evidence as the first line of treatment. Lateral patellar tracking at the knee joint is caused by increased knee abduction and distorted tibiofemoral rotation [18]. It has been established by some studies that runners with AKP have increased hip adduction and rate of hip rotation. It is proposed that single leg squatting and gait are the best activities for screening for

abnormal biomechanics related to AKP [17]. Additionally, AKP patients have minimal knee flexion and hip rotation. Apparently, reduced knee flexion acts as a compensation mechanism for AKP runners.

During running at first half of stance phase, there is eccentric cooperation of hip abductors and the lateral rotator muscle group of the hip to control adductive and internal rotation hip movement [19]. In cases where the hip's lateral rotator muscles are weak, there is an excessive femoral internal rotation at the stance phase of running. As a result, the quadriceps angle increases, which in turn increases the lateral force on the patella. The Q-angle explains why women have a higher risk of AKP diagnosis compared to men, since women have a larger hip adduction angle and valgus knee position compared to men, they have an increased Q angle and thus there is more pressure on the patella [18,20]. When considering an abnormality of the lower-extremity motions, it should be noted that segments can be affected from the ground up or from the hip and pelvis down or a combination of both [21]. For instance, during a stair descent a medial collapse of the lower limb could be the result of abnormality of lower-extremity motions originating from the hip, ankle and foot, or a combination of these (Figure 1).

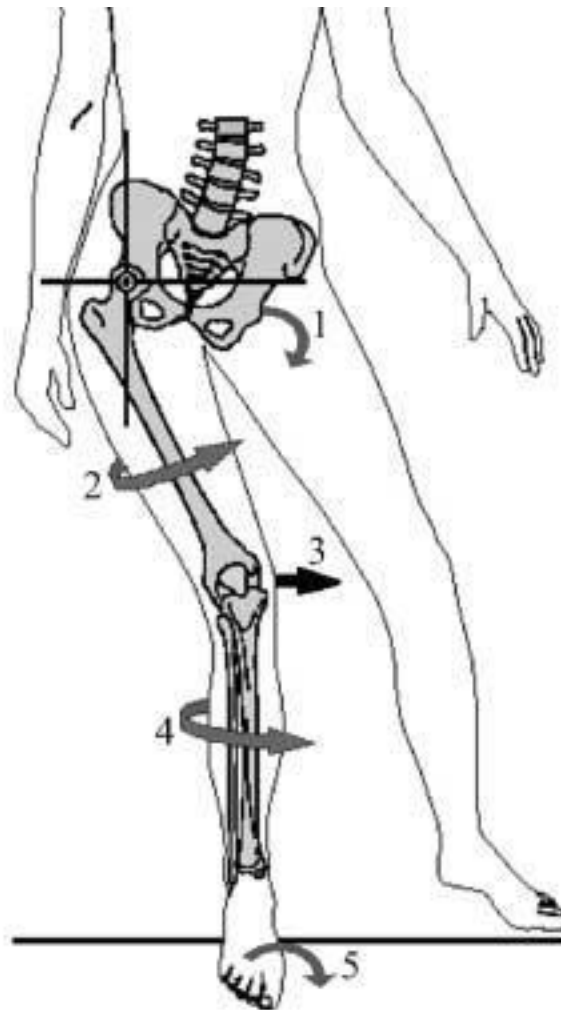


Figure 1. Schematic showing the potential contribution of the various lower-extremity segments to abnormal alignment: (1) contralateral pelvic drop, (2) femoral internal rotation, (3) knee valgus, (4) tibia internal rotation, and (5) foot pronation.

AKP TREATMENT

AKP affects the performance of athletes and training efficiency [17]. Therefore, there is an urgent need to treat AKP immediately once its signs are detected to improve the performance of an athlete and prevent adverse conditions, such as those associated with PFPS [16]. The impacts of AKP can be addressed by use of an anti-inflammatory drug or passive patellar maltracking correction by use of medially directed tape. Changing the type of exercise and losing weight can help relieve pain. While exercising, it is important to learn and perform exercises that strengthen and stretch the quadriceps and hamstring muscles. Taping techniques can also be used to realign the kneecap. During sports, it is important to ensure that one wears the correct sports shoes and for

orthotics to wear special shoe inserts and support devices [20]. In rare cases, surgery is used in the treatment of AKP to remove the damaged part of the kneecap and restructure tendons to assist the kneecap in moving more evenly [10].

KINESIO KNEE TAPE

Kinesio tape (KT) is a rehabilitation method that is used to treat knee injuries. Dr. Kenzo Kase developed Kinesio Tape in 1970; later in the 1990s, it was introduced into the United States [22]. In 2008, Beijing Olympics, Kinesio Tape gained international exposure triggered by volleyball players who have worn the multi-coloured version of the tape. Apparently, even up to date its popularity is still very high. Although KT is a new technique, currently it is

widely used by physiotherapists. KT is elastic since it stretches up to 130-140% and with favourable adhesion properties [24]. KT use is easy and also cost-effective [23]. KT maintains motion range while muscles are put on light, and facilitate functional stretch when in use. Apparently, the body moves normally while the fascia probably responds to the tape through proprioceptive and biomechanical methods [25]. KT is used to balance the muscle's effect on the knee and also help to relieve pressure on the kneecap and its tendons. KT is used to treat AKP by increasing circulation, offering support, and sustaining a range of motions without the downsides of wrapping or bracing [26]. Full KT knee support application is used to treat runner's knee, general knee instability, and patella tracking among others. KT application provides support, relieves pain and normalizes body mechanics without restricting motion or circulation unlike other treatment options. The material used to make KT is waterproof, and it is made up of ventilated material [27]. Also, KT has widespread clinical use due to its favourable adhesive property that facilitates its use and prevents allergic reactions. Once KT is applied, it draws the skin and probably widens the gap between the skin and muscle. However, it is known that KT can increase local blood and lymphatic circulation [33].

KT can be used by applying the tape in the direction that the muscle contracts, from the origin of the muscle to the insertion. This method enhances the contraction of muscles that are injured. Alternatively, KT can be adhered in a direction opposite to muscle contraction, from muscle insertion to origin [34]. This method hinders muscle overuse to avoid excessive muscle tension required in athletics. Therefore, Morris et al. [34] concluded that the KT material flexibility enhances it to stretch to 130% to 140% of its initial length. This flexibility enables different KT application methods on muscle, offering tension force to either pull or inhibit the contraction of muscles. Moreover, the folding of the skin, which results due to tape elasticity, probably increases local lymph and blood circulation, and hence removal of the metabolic substances [26]. Although several studies show that KT has positive effects, the results are inconsistent and few studies have looked into this [23]. Nonetheless, the use of KT is widespread in clinics and sports.

The available theoretical knowledge supports the hypothesis that KT enhances the stability of the joints by providing support to or around the muscle that is affected. Knee stability is crucial for the performance of athletic tasks. Thus, there is a need to maintain the

joint within physiological limits as well as prevent chances of mechanical overload [1,9]. The main complication of a knee injury is joint instability, which often results in the wearing out of the knee cartilage, the generation of early arthritis, and probably functionality changes such as problems with gait and moderately simple tasks such as squatting [26]. According to research [23], KT is used for neuromuscular re-education, for reducing pain, for performance improvement, prevention of injury and the improvement of healing and circulation. As such, KT is helpful for both uninjured and injured people [26]. It is argued that KT reduces pain through the provision of cutaneous stimulation through large afferent fibres acquired via deformation of the slowly adapting mechanoreceptors in the skin. Other researchers also propose that KT facilitates contraction of the muscles [40].

Two of the research studies [15,27] evaluated showed that, once KT is applied, there is a significant increase in isokinetic concentric quadriceps strength which results in an increase in endurance. The KT taping technique increases voluntary isometric concentration maximally during knee extension when compared to pre-treatment measures. For physically active individuals with anterior knee pain, the knee extensor strength and endurance can be increased by application of KT. Therefore, applying KT in physically active patients increases knee extensor strength and endurance while reducing pain during execution of functional performance tasks [5].

The stability of PF is dependent on the quadriceps and pelvic girdle muscles. Thus, a disparity of strength of the quadriceps muscle affects the contact and the stress of the cartilage joint which interferes with the pain pattern [41]. In cases where there is insufficient strength to stabilize pelvic muscles, such as abductors and the lateral rotators of the hip, this may result in adduction and extreme medial rotation of the hip in the closed kinetic chain [16]. Apparently, this can be altered by the patellar biomechanics, accelerating the contact between the lateral condyle and the lateral facet of the patella, activating and intensifying the painful condition. Although this study did not explore gender as a variable in pain score, the findings of previous research [24] suggest that hip muscle weakness is a common feature among women who report anterior knee pain.

A study [13] showed that knee muscle extension is the most affected muscle in individuals with anterior femoral pain. Furthermore, weak quadriceps muscles

are a risk factor for developing PFPS. Therefore, knee muscle extension and quadriceps positively influence the need for rehabilitation. The major dynamic patella stabilizer in the femoral trochlea is the quadriceps [42]. A decrease in the strength of the quadriceps is thus a risk factor since it is directly related to anterior knee pain incidences and also plays a significant role in the development of PFPS [7]. This is one explanation of the significant outcomes reported in this research regarding the role of KT in pain reduction among patients with anterior knee pain.

According to research [26], KT may be able to minimize pain and change patellofemoral kinematics. KT also reduces muscle spasms and swelling. Several studies [23,24,26] also confirm the efficacy of KT tape in the treatment of acute sports injuries. This is because KT instantly reduces pain, improves the contraction of the muscle and speeds up the athlete's recovery process to get back to normal activities. Although the efficacy of KT is supported by various findings, there is limited evidence regarding its benefits for spot injuries. Additionally, there is limited evidence of the effects of KT on kinematic gait pattern and pain in individuals with knee injuries such as AKP.

AIM OF THE RESEARCH STUDY

Scientific studies are important to better inform clinicians and the public on the effect of knee tape on kinematic gait patterns and pain in runners with AKP. Therefore, this research study is meant to investigate the short-term effects of KT on kinematic gait patterns and pain level among runners with AKP.

METHODS

RESEARCH DESIGN

The current study is a cross-sectional study. In order to answer the research question, we have used the 3D

Gait Biomechanical Analysis System in order to measure the kinematics of the knee and hip during running. Two conditions were compared to each other; running with tape and without tape. The measurements have taken place in the Sportmedic Centrum in the UMCG in Groningen.

3.2 RESEARCH POPULATION

It is indicated that for a cross-sectional study to be able to generalise the findings for validity, the study should be a representative of the whole population (28). 24 runners aged between 18 and 50 years were recruited for this study. The runners were recruited via social media and in gym advertisements and physiotherapy practices. Before commencing the study, all the participants received a letter containing the aims and objectives of the study together with their role in the study. The participants were required to sign an informed consent before being included in the study. They also completed a baseline questionnaire having questions concerning their personal information and particular questions regarding running.

3.3 INCLUSION CRITERIA AND EXCLUSION CRITERIA

Inclusion criteria included the characteristics that the participants had to have in order to be included in the study. All the participants used were voluntary and suffering from anterior knee pain and of age between 18 and 50 years. Exclusion criteria entail the characteristics that disqualify prospective participants from being included in the study. People who had other injuries apart from knee pain were excluded from the study. Additionally, individuals who never exercised frequently specifically less than twice a week were also excluded. Moreover, neurologically impaired individuals were excluded from the cross-sectional research. Table 1 shows an overview of the inclusion and exclusion criteria.

Table 1: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Participants age between 18 and 50 years	Neurologic impairments
Athletes with anterior knee pain	Injuries other than anterior knee pain
Voluntary participation in the research	Training less than twice per week

INSTRUMENTS

3D Gait Biomechanical Analysis System was used. 3D biomechanical gait analysis techniques help professionals to diagnose, plan and make decisions for patients and athletes who have an impairment or are suffering from an injury. 3D biomechanics are very common in sporting and clinical applications. As such, this research used 3D biomechanics to compare running with and without tape. The measurements used are from Sportmedic Centrum in the UMCG in Groningen.

PROCEDURES

Questionnaires were used to collect basic information concerning personal characteristics, factors related to sports and factors related to the injury. Also, the severity of the knee pain of the participant was assessed by use of Kujala questionnaire and OSTRC Overuse injury questionnaire.

Kinematic data were collected by use of 3D Gait system. The 3D Gait system has the capacity to collect 250 records per second and with the capability to record all joint angles in the frontal, transverse and sagittal plane at 250 Hz sampling frequency. The

research made use of three different cameras and retroreflective markers. Cameras were placed behind the treadmill at approximately 1-2 meters and were adjusted to the right height, as shown in Figure 2.

The tracking markers were located in clusters of 4 on the upper leg (femur), lower leg (tibia) and around the pelvis (Illustrated in Figure 3). These markers were affixed to thermoplastic shells and attached to straps with Velcro, and secured around the pelvis, thigh and shank. The pelvic strap must be placed over the spina iliaca posterior superior and secured with Velcro. The rearfoot retroreflective markers were attached directly on the participant's shoes and secured with non-reflective tape. The joint markers were applied to the left and right trochanter major, the lateral and medial knee joint space and the lateral and medial malleoli. The anatomical coordinate systems are developed by anatomical markers to perform a static calibration before taking the measurements. The anatomical markers were removed and a standing calibration trial collected and leaving the tracking markers for running on the treadmill.

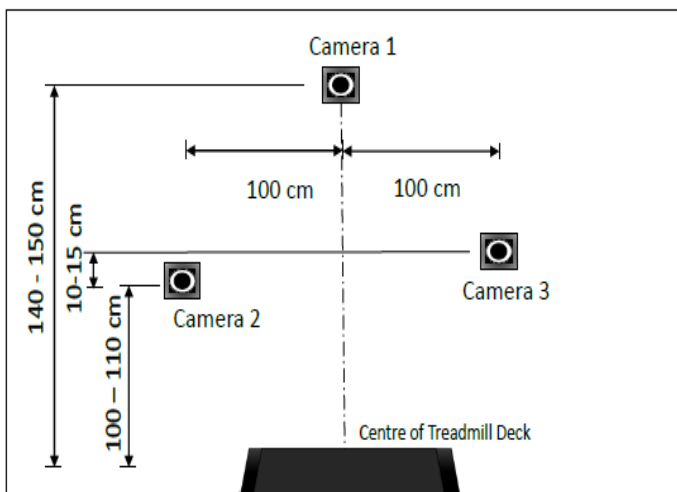


Figure 8: Recommended back wall camera placement geometry

Figure 2. Placement of camera's 3D Gait system collection



Figure 3. Markers placement for kinematic data

Before running, participants who met inclusion criteria undertook six-minute warm-up on the treadmill environment. This involved jogging under low-intensity and giving the participants chance to familiarize with the treadmill environment. During warm-up, participants were given a chance to select running pace that best represented the typical training pace for the participants. Participants were given the freedom to either increase or decrease the treadmill speed until they get a comfortable pace. Kinematic data were collected in two sets one with KT and another one without. Kinesiotape (CureTape) was used and applied to the most symptomatic (painful) knee of each participant. This research involved a combination of two knee tape techniques which include; the 'ligament' technique and the 'patella tracking' technique. Both methods are shown in Figures 4 and 5 and are used in the UMCG by physiotherapists in patients with anterior knee pain.

The participants were never allowed to know the exact time when measurements started. This was important to prevent any possible adjustment of their gait pattern. A randomized program was used to ensure that half of participants first runs without the KT and the other half first runs with it. After first measurement, the participants were asked to fill VAS score form (Appendix 4) to show the level of pain during running. Subsequently, the second analysis was performed and the VAS score form was again filled.

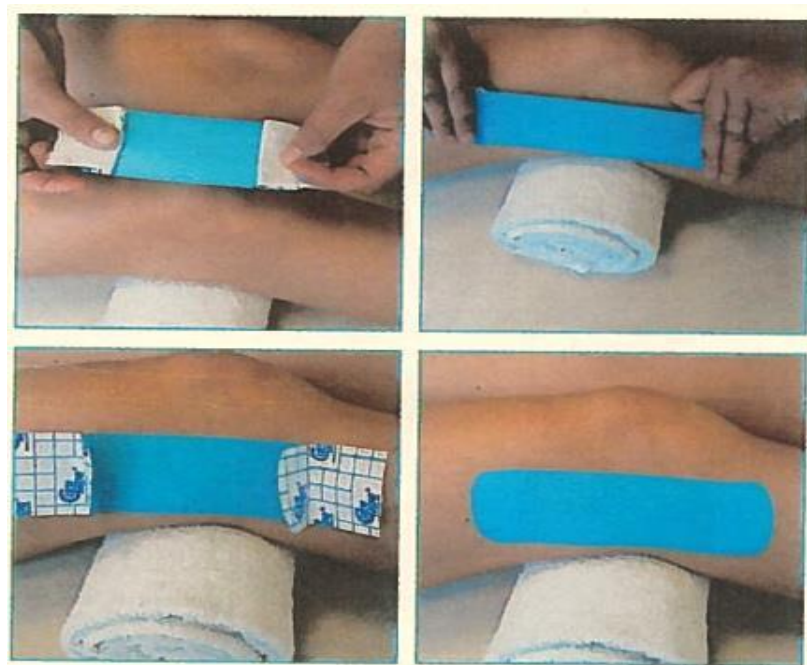


Figure 4: illustrating the use of the ligamentary technique.

Figure 4 illustrates that the Kinesio tape is completely stretched and paced down from the middle. Edges of the tape are placed on the skin without stretching. The tape plays a crucial role of pulling from the edges to the middle and supports the collateral ligament of the knee. As a result, the movements in the frontal plane are stabilized.



Figure 5: The patella tracking technique.

Figure 5 shows that how a base of the tape is placed on the tibia tuberosity. When the patient is bending his knee slowly, the two strips of the tape are applied around the patella at the same time, cranially, to go beyond the patella slightly. The lateral strip is applied with more stress when compared to the medial strip. This ensures that the patella is stabilized in the knee joint.

DATA COLLECTION

The 3D gait system was used to collect all joint angles that took place at the time of running. During stance phase, each participant's maximum joint ankle angle, hip, and knee were recorded in Excel in the three anatomic planes. Later, each participant's average peak angle was calculated both with and without KT tape. Kinematic variables of interest included the angular peaks of the knee abduction (KABD) and hip adduction (HADD) in the frontal plane. Additionally, in the transverse plane we looked at the internal knee rotation (KIR) and the internal hip rotation (HIR). Finally, we were interested in the knee flexion (KF) in the sagittal plane. The angular peaks of the joints of the participants without tape and with tape were compared. Each participant's data was keenly scrutinized to check for breaks that takes place as a result of marker occlusion. All data from each participant were averaged based on 10 steps prior to statistical analysis.

VAS score was used to measure pain, and it ranged from zero in case of no pain and ten in cases of

maximum pain. After each measurement, the participants were asked to place a circle around the number that indicated the amount of pain experienced while running with tape and without tape.

STATISTICAL ANALYSIS

The SPSS version 24 was used for statistical analysis. The first consideration was the distribution of data. We expected that the data would not be distributed normally. As such, there was a need to perform non-parametric tests. Because running with and without tape had to be compared to the same person, the Wilcoxon-pair signed-rank test was used to compare running with KT and running without KT. A variation was considered significant at a p-value ≤ 0.05 .

RESULTS:

All the 24 participants used in the research study met all the inclusion criteria and completed the study. The following are the participant's demographic results. The Kujala mean pain index of 56 (Table 2), shows that participants with anterior knee pain had a limited training participation. Notably, scores of 70 in the Kujala questionnaire indicate a mild disability. Also, based on scores recorded, the involved participants were under moderate disability category. OSTRC overuse injury questionnaire scores that range from 0-100 also indicated a mean score of 51 shows participants who can participate in training but with strain.

Table 2: A summary of the participant characteristics (mean +/- SD).

Gender (male/female)	15/9
Age	24.75 (3.79)
Height (cm)	174.33 (3.97)
Weight (kg)	69.04 (6.94)
Treadmill velocity (km/h)	9.99 (1.10)
Years of running	2.75 (0.79)
Kujala	56.95 (7.56)
OSTRC Overuse Injury	51.75 (10.89)
Dominant leg	18 right/6 left
Painful leg	21 right/3 left

KINEMATIC VARIABLES

In the kinematic variables considered in the study, it was found that there was no significant difference between running with tape and running without tape (Table 3, $p > 0.05$). The results on knee abduction showed that there were no statistically significant differences in peak knee abduction angle between

running with a tape and running without a tape. This was also reflected on peak knee internal rotation and peak knee flexion. Results on hip adduction and hip internal rotation shows that no statistically significant differences have been found between hip adduction angle when running with tape and without tape, neither for hip internal rotation. The Means and Standard Deviations are provided in Table 3.

Table 3: Mean (peak) joint angles in degrees ($^{\circ}$), VAS pain score, for measurements without and with tape, $n = 24$.

Variables	Without tape	With tape	P*
KABD($^{\circ}$)	-5.61 (6.8)	-5.93 (9.5)	0.391
KIR($^{\circ}$)	-8.49 (17.6)	-10.06 (18.2)	0.511
KF($^{\circ}$)	45.42 (6.4)	44.69 (5.9)	0.189
HADD($^{\circ}$)	3.54 (3.6)	3.23 (3.3)	0.103
HIR($^{\circ}$)	14.03 (9.7)	15.60 (5.6)	0.627
VAS score	6.37 (1.2)	5.04 (1.3)	0.001

KABD = knee abduction, KIR = knee internal rotation, KF = knee flexion, HADD = hip adduction, HIR = hip internal rotation.

*P-value ≤ 0.05 is considered significant.

PAIN LEVEL

The results showed that there was a significant difference in pain scores measured between the running without tape and with tape. The pain level was reduced with KT compared with no KT. The mean VAS score was 6.37 before taping, and significantly decreased to 5.04 after taping ($P < .05$) Table3.

DISCUSSION:

The purpose of the study was to investigate the effect of KT on knee and hip kinematics. In addition, the effect of KT on the pain score has also been investigated. No significant difference was observed in knee and hip kinematics between running without KT and with KT. However, there was a significant difference observed in pain score. The pain level was significantly reduced in running with tape compared with running without tape.

COMPARISON WITH THE LITERATURE

Notably, in recent years, the popularity of the application of KT has significantly increased. However, there has been conflicting evidence regarding its efficacy (29). The findings of this study and those of other supporting studies indicate that KT helps in reducing pain and consequently improving functional performance.

HIP AND KNEE KINEMATICS

This study did not find a significant relationship in knee and hip kinematics when a comparison of running with tape and running without tape was made. Research on the effect of KT on kinematics is very limited. A study has shown that the tape reduced knee flexion in healthy people during the stance phase during walking (26). The reduction in knee flexion reduces the stress on the knee joint. However, in this study, no difference has been found in knee flexion between running without tape and running with tape.

In knee abduction, there were no statistically significant difference (p -value = 0.39). These findings differ from the findings in a study that explored the impact of KT on performance among horse racing jockeys. This study established that participants could perform a knee flexion/extension at 60° per second and 180° per second in an isokinetic dynamometer before and after KT was applied; thus the study found a significant difference (30). Although the theory proposes that KT plays a significant role in enhancing knee abduction by increasing the circulation and hence improving the muscle function; however, more recent studies

exploring healthy people also indicated that KT use does not affect circulation nor the volume of the muscle, and it does not improve the function of the anaerobic muscle (7,31). Although previous research found that KT improves sensory stimuli to the skin and via the underlying fascia through interconnections found between connective tissues increases motor response and muscular action potential (32), the findings of this study do show statistically insignificant relationships between the study variables and KT use.

Knee internal rotation was not significantly affected by KT use among the participants in this study. This indicates that KT stabilizes the knee joint without affecting its kinematics. However, research has indicated that other tapes, such as an iliotibial band, is as helpful as a hip stabilizer and affects hip abduction and knee internal rotation (39). KT operates as a means of improving joint stability as well as decreasing pain. In addition, the ligamentary tape technique would theoretically stabilize movements in the frontal plane (50). This could be seen in the knee abduction angle, which is again related to the hip adductive angle (21). However, in this research no differences have been found in these angles.

KT AND PAIN REDUCTION

Since the pain is the main symptom and the target of treatment in AKP, we investigated the effectiveness of KT by measuring the subjective response of the participants using the VAS score. It has been reported that a reduction of 13mm is the minimum clinically significant difference in VAS score (49). Another study has demonstrated that a minimum level of 12mm is necessary to result in a significant reduction of pain when using an orthosis (48). In the current study, the reduction of the overall mean of the VAS score after taping was 13.3mm, indicating that the pain of AKP during running could be significantly reduced by KT. This finding can be interpreted to mean that KT can produce a clinically relevant reduction of anterior knee pain.

The results of this study suggest that Kinesio taping provides an immediate reduction in pain level in symptomatic individuals and improves their performance of functional tasks. The VAS scores support the use of KT to reduce anterior knee pain. An immediate reduction in pain level, as quantified by the VAS, with the application of Kinesio taping is consistent with previous findings (15,26,27,48,49). Additionally, empirical evidence based on studies carried out by Campolo et al. (43) and Osorio et al.

(44) confirm that KT effectively reduce pain during kinetics. This is because taping over the skin stimulates cutaneous mechanoreceptor and stimulates afferent feedback to the central nervous system, which leads to a decrease in pain. However, no significant kinematic alterations were found after patellar tape application. Thus, changes in pain did not seem to influence hip and knee kinematics during running.

According to research by Campbell and Valier (13), KT can be used alone as a traditional physical rehabilitation method to reduce pain in patients experiencing anterior pain without any risk of negative side effects. Use of KT as a pre-treatment measure during sports activities significantly decreases pain during sports. Based on several studies (15,26,27), KT significantly reduces pain in PFP patients regardless of whether it is used alone, in connection with traditional physical rehabilitation or with McConnell taping (32). Notably, in all instances, there is no sign of negative side effects whatsoever. Therefore, AKP patients can easily apply KT, it is also time and cost-effective, and its use is not related to a known negative side effect.

The current study's findings regarding the impact of KT on pain reduction in anterior knee pain call for further research. However, the reduction of anterior knee pain is a clinical challenge due to the multifactorial nature of the development of AKP (5). The purpose of this study was to investigate the effect of KT on AKP. It is important to note that the cause and the origin of the pain is very complex and not fully understood. Peripheral and central mechanisms as well as local tissue changes seem to play a role in AKP (48). Future research is required to gain more insight into these mechanisms.

POSSIBLE MECHANISMS OF PAIN REDUCTION

KT is made up of thin cotton and acrylic-acid-consisting porous fabric. As such, Kinesio tape is a unique non-latex adhesive patch. Its function in pain reduction can be explained on the basis that once it adheres to the VMO muscle of a patient with anterior knee pain, proprioception input increases, facilitating muscle contraction (35). Additionally, the tape is applied over the iliotibial band, tensor fasciae latae and VL muscle to hinder tension of the muscles as well as relax the muscle. Research (8) established that use of KT reduces the pain associated with PFPS, though it never changes patellar alignment. Kinesio taping tugs on the skin to widen the gap between the skin and the muscle. It also reduces tissue oedema as well as enhances circulation of

blood and lymphatic fluids. In this way, Kinesio tape effectively relieves pain. Another study (33) also established that taping reduces swelling and muscle spasms of patients suffering from PFPS. Additionally, Kinesio taping is used in the treatment of acute sports injuries due to its nature of relieving pain immediately, improving muscle contracture and accelerating the return of the athletes to normal activity (16). However, there is little research on the working mechanisms of KT.

Based on studies carried out by Chang et al. (36), Kinesio taping stimulates cutaneous mechanoreceptors and improves knee proprioception. This in turn increases sensory input feedback to the central nervous system, hence reducing pain. The taping technique is based on the gate control theory regarding pain modulation mechanism (35,37). Moreover, KT reduces pain in PFPS patients by facilitating contraction of the quadriceps muscle; this increases the strength of the muscles which provide stability of patellar component, sustaining normal patellar tracking and hence reducing pain (38). Moreover, KT increases sensory input in the skin as well as stimulates proprioception to trigger muscle force control. Kinesio taping of muscle also helps joint mechanoreceptors develop joint position sense, hence assisting cutaneous mechanoreceptors to excite the Golgi tendon organ or muscle spindle. Kinesio taping effectively manages patellar tracking via increased muscle force sense, thereby relieving pain in PFPS patients (14).

Another possibility is that the reduction in pain was the result of the placebo effect of the tape, regardless of the direction in which the tape was applied. We cannot draw a conclusion because we did not have a placebo tape group in our study. However, previous studies have indicated that therapeutic taping has a greater effect on pain reduction and functional improvement than placebo taping or control conditions (45,47). Nevertheless, another study (47) reported no significant differences between therapeutic and placebo taping techniques on perceived pain and neuromuscular activity. Further research is required to assess the influence of different application techniques of KT on pain level and function, as well as the potential placebo effects of these techniques.

IMPLICATIONS, LIMITATIONS, RECOMMENDATIONS AND CONCLUSIONS

CLINICAL AND SCIENTIFIC IMPLICATIONS

There has been minimal research conducted on KT methods and their influence on hip and knee kinematics and pain in runners with AKP. Determining the effects of KT, compared with no tape, on kinematics and pain during running in an AKP sample may provide support for the use of KT to manage AKP. The findings of this study may inform runners, coaches and physiotherapists about the pain reduction effects of KT in AKP runners.

LIMITATION AND EVALUATION OF THE METHODS

There are limitations to this study that should be considered. First, the taping methods selected in this study involved a combined KT technique that has been used in the UMCG. Other forms and other techniques may have different effects that may be interesting to investigate. Furthermore, AKP diagnosis is a clinical assessment diagnosis and it is difficult to confirm using imaging techniques. There was no magnetic resonance imaging done to exclude other knee pathologies. Therefore, we might have included patients with other knee pathologies that cause anterior knee pain. The research population had a small age range (19-30 years), a small sample size ($n = 24$) and it included very few females. An advantage of the lack of differences between the participants is that the research population can be considered homogeneous. In addition, the participants had to perform a relatively simple running task at a constant speed, which may not sufficiently replicate normal recreational running to cause change in the lower extremity kinematics. In future studies, it would be useful to perform more exhausting running tasks. Another limitation of this study is that both the researcher and the participants were aware of whether or not KT was used during the measurement. This can lead to bias during testing and analysis. However, it was an objective measurement because the angles were measured by the 3D gait system and not physiologically assessed by the investigator. This ultimately resulted in a reduction of this bias. Additionally, by using a randomization program which was part of the research procedure, the risk of bias was greatly reduced.

RECOMMENDATIONS FOR FUTURE STUDIES

Although KT was found to have a positive effect on pain reduction, the mechanism that reduces pain remains unknown and beyond the scope of this study. Therefore, future studies should focus on determining how KT reduces pain. As the method of KT used in this study created no significant difference in hip and knee kinematics in runners with AKP when

compared with no tape, it appears that this method is not different from non-tape. The mechanism of action however may be different in asymptomatic people or in patients with specific running complaints, such as tendinitis. Therefore, to determine the effect of this method of KT on asymptomatic people or runners with injuries other than AKP, further research is recommended. Additionally, future research should focus on methods of combining KT with various techniques for improvement of different athletic injuries. This study has investigated the short-term effect of KT on pain reduction. Using KT over a longer period of time may result in different effects. This was seen, for example, in a study investigating subjects with lateral elbow pain; a bandage had a positive effect on pain in the short term, but this effect disappeared in the longer term (46). Future research should therefore focus on the long-term effects of KT as these might be different. Finally, in order to be able to exclude a possible psychological effect, we recommend including a placebo tape group in future studies.

CONCLUSION:

This research establishes a positive relationship between the use of KT and reduction of pain level among patients with anterior knee pain. The present study found that KT did not affect the knee and hip kinematics during running in a sample of AKP runners, whereas KT reduced their pain compared with AKP runners who did not use KT. The mechanism that causes this reduction in pain level remains unknown. This raises questions about the cause of the positive effects of KT on pain measured in earlier studies and experienced in practice. However, patellar taping seems to be a safe and effective way to reduce the painful symptoms of AKP and it may be beneficial in allowing patients to engage in functional rehabilitation exercises. Our study contributes to the current body of literature investigating KT in sport. Our findings may also contribute to the treatment of AKP. Research involving a larger, more specific population and multiple taping techniques to determine the true effect of KT is therefore recommended.

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